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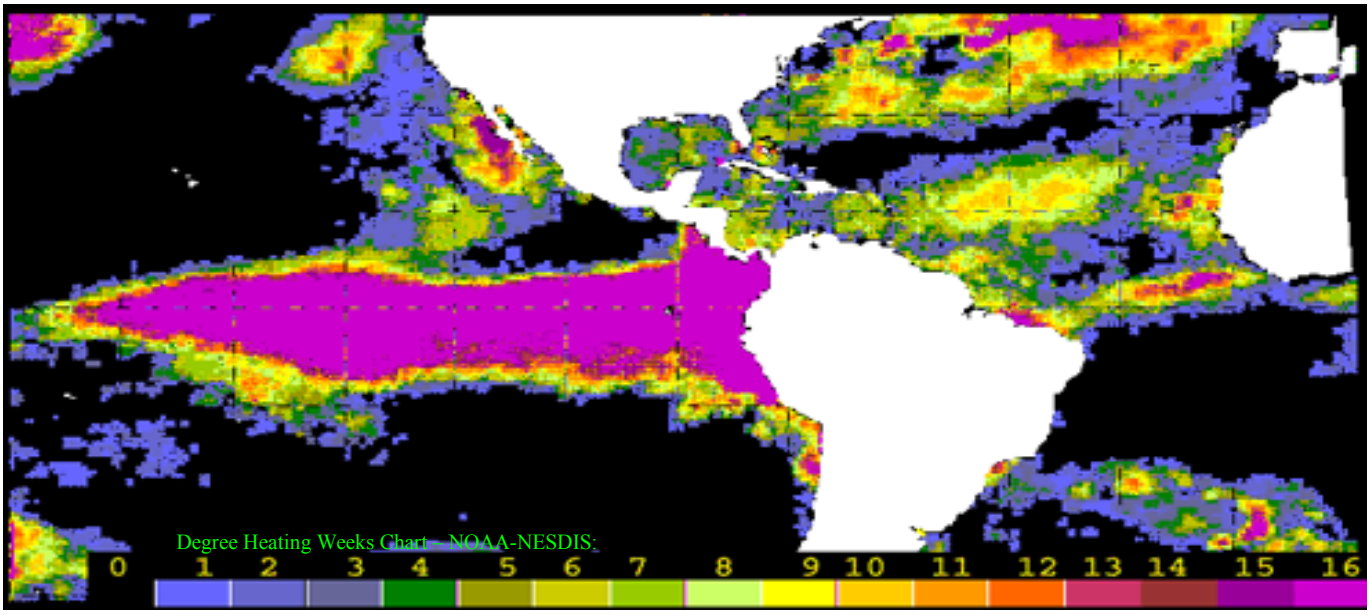
Workshop Report

National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite, Data, and Information Service (NESDIS)

Coral Reef Team Workshop
Friday, June 2, 2000



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1.0 EXECUTIVE SUMMARY

The Coral Reef Protection Executive Order 13089 issued on June 11, 1998 called on the federal government to strengthen its stewardship of coral reef ecosystems in the United States. The order assembled a National Coral Reef Task Force (CRTF) to coordinate national efforts to reduce adverse impacts on coral reef systems. The U.S. collective response to the coral reef crisis culminated in the 1999 CRTF National Action Plan to Conserve Coral Reefs. This plan puts forth a "comprehensive road map" for federal, state, and local action to preserve coral reef ecosystems. The National Environmental Satellite Data and Information Service (NESDIS) responded by forming the NESDIS Coral Reef Team in March 2000. Currently, NESDIS performs a variety of coral reef activities including monitoring, mapping, data distribution, paleoclimatology, and technology transfer, with a total budget of at least $1.0M annually. The purpose of this team is to bring all NESDIS coral reef activities under a focused, coordinated NESDIS coral reef program that addresses the priorities of the CRTF National Action Plan.

A Coral Reef Workshop was held on June 2nd , 2000 to present current NESDIS coral reef activities and formulate guidance for the evolution of a coordinated NESDIS coral reef program. Representatives from the National Ocean Service were also invited. The NESDIS coral reef activities are as follows:

- **National Oceanographic Data Center (NODC)** activities center on the development of a state-of- the art Coral Reef Data and Information Management System (CRDIMS). This system is designed to address the data access needs of coral reef scientists and managers, academia, the general public and other interested groups. Ideally, CRIDMS development will follow the prototype approach successfully utilized in the Harmful Algal Bloom database development.

- **National Geophysical Data Center (NGDC)** is involved in two coral reef endeavors, paleoclimatology and coral reef mapping and monitoring. The former entails deciphering past climate variability from corals and tree ring cores. Potential coral reef applications include reconstructing the coral reef environment in the past and determining what corals have experienced prior to man's influence over the full range of natural variability. This program also seeks to develop coral reef bleaching proxies to better understand relationships between bleaching and past climate variability. NGDC's coral reef mapping and monitoring activities include collection and processing of aerial photographic, high-resolution satellite, and hyperspectral data to support the National Ocean Service's (NOS) coral reef mapping and monitoring of coral reef health.

- **Office of Research and Applications (ORA)** and the **Office of Satellite Data Product Distribution (OSDPD)** are working together on coral reef satellite monitoring. The goal of this joint effort is to continue development of a satellite-based early warning system for coral reef bleaching. Current activities are focused on transitioning coral reef products (Hotspot maps, Degree Heating Weeks (DHW) Maps, and the Tropical Coral Reef Bleaching Indices page) based on 50 km Sea Surface Temperature (SST) data from

research to operational status. Efforts also involve increasing resolution of HotSpot maps from 50 to 9 km as well as continuing examination of relationships between bleaching and SST. The ORA-led Coral Reef Watch (CRW) initiative combines efforts throughout NOAA with the United States Geological Survey (USGS) and international collaborators to establish an early warning system for coral reef bleaching events based on *in situ* and satellite observations. The development of this system will utilize paleo records, *in situ* monitoring, and satellite HotSpot data and depend on international and interagency cooperation.

Based on coral reef activity summaries and discussions as well as the relevance of current NESDIS activities to the CRTF National Action Plan, the NESDIS coral reef team agreed on five recommendations to facilitate the establishment of the coordinated NESDIS coral reef program. These recommendations follow:

1) NESDIS should continue its current coral reef activities, while making appropriate changes when necessary to form an integrated NESDIS coral reef program.

2) NESDIS's coral reef-related activities should be conducted within the framework of a larger NOAA partnership. NESDIS should coordinate, where possible, its coral reef program activities (e.g. timing, location, and goals) with coral activities in other NOAA line offices.

3) To facilitate the development of a NOAA-wide coral reef partnership and guide future coral reef activity planning, the workshop recommends developing one to two regionally focused coral reef pilot projects. Pilot project locations should coincide with localities where NOAA coral reef activities converge.

4) Greater overall coordination of NESDIS's coral reef activities with the other NOAA line offices. This is particularly pressing as NOAA strives to provide the national leadership in coral reef ecosystem stewardship and data-information services.

5) Despite major Federal, State, and local efforts in coral reefs, most data on these important ecosystems are poorly organized, scattered and cannot be found online. A follow-on workshop (involving all of the current participants as well as the National Coastal Data Development Center and representatives from other NOAA coral activities) should be convened to address coral reef data management and information services issues.

Within the framework of the CRTF National Action Plan, NESDIS's coral reef activities support the Action Plan's key conservation objectives to varying degrees. NESDIS is most strongly involved in coral reef mapping, assessment and monitoring, and research, key action areas aimed at understanding coral reef ecosystems. NESDIS has other coral reef activities that support the goal of reducing adverse impacts of human activities. NESDIS coral reef activities strongly support key actions to establish Marine Protected Areas (MPAs), reduce global threats to coral reef ecosystems, and create an informed public.

Yet to be resolved is the future role that the new National Coastal Data Development Center will have, and how that role might affect the balance and distribution of current and existing NESDIS activities.

2.0 INTRODUCTION

Federal agencies under Executive Order 13089 are required to strengthen their stewardship activities for the Nation's coral reef ecosystems. To coordinate national efforts, this order established the National Coral Reef Task Force (CRTF). In 1999, the task force combined contributions from working groups comprised of governmental and non-governmental individuals to produce the National Action Plan to Conserve Coral Reefs. This plan serves as the nation's guide to healthy coral reef ecosystems.

In March 2000, NESDIS formed a Coral Reef Team to ensure NESDIS support of the CRTF National Action Plan. NESDIS currently performs a suite of coral reef activities ranging from mapping, monitoring, and research, to technology transfer and data management. The goals of the NESDIS coral reef team are to combine these efforts under an integrated coral reef program, develop a strategic plan for this program, and improve working relationships between the NESDIS coral reef program and other NOAA line offices involved in coral reef work.

Team members from the Office of Research and Applications (ORA), the National Oceanographic Data Center (NODC), the National Geophysical Data Center (NGDC), and the Office of Satellite Data Products and Distribution (OSDPD) met on June 2, 2000 for the first NESDIS coral reef team workshop. A list of participants is included as Appendix A. All NESDIS offices currently involved in coral reef activities were represented. The newly-created National Coastal Data Development Center (NCDDC) was not represented at the workshop. Three representatives from the National Ocean Service (NOS) and one from the Australian Institute of Marine Science (AIMS) participated in portions of the workshop. The workshop purpose was to promote team awareness of all NESDIS coral reef activities, assess the relevance of these activities within the context of the CRTF National Action Plan, explore opportunities for collaboration with other NOAA line offices, and ultimately develop a set of recommendations for the development of a NESDIS coral reef program.

In an effort to understand where current coral reef resources are focused, each team member was asked to summarize their organization's ongoing coral reef activities and the relationship of those activities to the CRTF National Action Plan key conservation objectives. Summaries included information regarding the objectives, funding, and offices and staff involved. Appendix C outlines NESDIS coral reef activities in mapping, monitoring, data management, and research.

Appendix D provides a matrix summary of these activities' relationship to the CRTF National Action plan's key conservation objectives. Each respondent was also requested to rate the degree to which activities supported each of the key conservation objectives.

The matrix summary suggests that NESDIS activities most strongly support the "Understanding Coral Reef Systems" key conservation objectives to map, assess and monitor, and research coral reef ecosystems. NESDIS coral reef activities respond, secondly, to the CRTF goal of reducing adverse impacts of human activities by strongly

supporting key conservation objectives to establish Marine Protected Areas (MPAs), reduce global threats, and create an informed public. All team members reviewed the activities summary and key conservation objectives matrix reports prior to the workshop.

3.0 WORKSHOP SUMMARY

The workshop agenda is provided in appendix B. The following presents a summary of the workshop presentations on coral reef data products and services, as well as partnerships with other programs.

3.1 National Oceanographic Data Center (NODC)- Global Coral Reef Data and Information Management System (CRDIMS) (Dr. Anthony Picciolo and Michael Ford)

NODC reported on the development of an integrated Global Coral Reef Data and Information Management System (CRDIMS). This system is being designed to address the data access needs of coral reef scientists and managers, academia, the general public and other interested groups. NODC considered the CRTF Atlantic and Pacific work groups suggestions in defining priority data sets and geographic regions. NODC is working with NOS and the Office of Oceanic and Atmospheric Research (OAR) on this activity. The management system will be Web-enabled and allows integration of biological, physical, and geological data from *in situ* monitoring and research with digital photographic and video media, aerial and satellite data products, biodiversity and biogeographical data, and bibliographic information. Data are being prepared for inclusion in Geographic Information Systems. Additionally, CRDIMS anticipates disseminating CD-ROM products on specific coral reef systems and topics. A prototype system is located at: http://www.nodc.noaa.gov/col/projects/coral/Coralhome.html**.** The prototype system includes sample data sets and linkages to other federal and non-federal databases and collections. As NODC builds this data management system, they will accommodate evolving software and information sources.

The process of developing the proposed CRDIMS involves four steps. The first two are nearly complete, the latter two are underway. First, NODC performed a needs assessment to identify gaps in coral reef Web-accessible data and services. They identified Web-based coral reef distribution centers and determined the information or services currently available and proposed for each Web-site. The results of this assessment are found in Appendix E. CRDIMS will provide the most comprehensive database, offering access to an array of coral reef data through a single location.

The second step was to define the core functions CRDIMS must support. NODC defined 10 core functions that correspond to four major areas; data archive, access, dissemination, communication and data exchange. The Concept of Operations Document found in Appendix E lists the core functions CRIDIMS must perform.

The final two steps entail performing a capacity analysis and developing an implementation plan. The former will define currently available NODC systems and

what must be created to support CRDIMS. The latter will define a logical plan of action and designate resources for CRDIMS.

The CRDIMS activity directly supports the CRTF National Action Plan key conservation objectives in the areas of mapping, monitoring, assessment, research, and creating an informed public. (Appendix D)

3.2 National Geophysical Data Center (NGDC)

3.2.a *Paleoclimatology (Dr. David Anderson)*

NGDC reported on their Paleoclimatology Program, specifically on deciphering past environmental variability from paleo evidence. The program's mission is to catalyze an understanding and prediction of interannual to centennial climate variability. To meet this mission, the NGDC paleoclimatology program archives and distributes data regarding past climates and environments from coral and tree paleo-evidence and funds, with the National Science Foundation (NSF), extramural research programs to create new paleo records. Data from the Annual Records of Tropical Systems (ARTS) program demonstrate the success of paleo-evidence for reconstructing annual climate records of tropical systems. Potential coral reef uses of these records include reconstructing the coral reef environment in the past, and determining what corals have experienced prior to man's influence over the full range of natural variability. The paleoclimatology community needs to recognize the potential coral reef applications of their work before coral reef funding applications progress. NGDC plans to address this issue while increasing extramural research to include more sites and new proxies (i.e. bleaching). NGDC envisions working closely with NODC on their database for coral paleoclimate observations.

Currently, this activity supports the CRTF National Action Plan key conservation objectives to improve coral reef research, mapping, and monitoring and assessment. Also, the paleoclimatology program indirectly supports CRTF efforts to reduce global threats and create an informed public. (Appendix D)

3.2.b. *Remote Sensing (Dr. Chris Elvidge)*

NGDC is currently active in several coral reef remotes sensing efforts, several in cooperation with the National Ocean Service coral reef mapping team. First, NGDC currently is assembling georeferenced orthophoto mosaics from an aerial platform for the Caribbean and Hawaii that serve as the base layer for NOS coral reef mapping. Details are posted at http://biogeo.nos.noaa.gov/benthicmap/pacific/. NGDC is working with NODC to make orthophoto products available through CRDIMS. Second, granted National Imagery and Mapping Agency (NIMA) approval, NGDC is generating degraded resolution (1+ m) images of coral reef areas from Department of Defense satellite images. Collections are in progress for a large number of sites including outer Hawaiian Islands and U.S. Pacific territories. Third, NGDC is beginning to generate orthophoto mosaics of reef areas based on commercial and public satellite imagery. A verbal agreement to collaborate on this topic was made with Space Imaging that operates the IKONOS

satellite. Finally, NGDC is working to develop the capability to map reef composition and condition using hyperspectral data. A five-year Cooperative Research and Development Agreement (CRADA) on hyperspectral remote sensing of coral reefs is being implemented with Analytical Imaging and Geophysics. NOS and the National Aeronautics and Space Administration (NASA) have already acquired large volumes of airborne hyperspectral data of Hawaiian reefs during the past several months.

NGDC needs to further develop the use of hyperspectral remote sensing for coral reef mapping and monitoring in collaboration with offices providing *in situ* groundtruth capabilities. Hyperspectral remote sensing offers the capability to map not only reef locations but also reef composition and condition.

These activities support many of the CRTF National Action Plan key conservation objectives, with the strongest support in coral reef mapping, monitoring, and research. (Appendix D)

3.3 Office of Research and Applications (ORA)/Office of Satellite Data Processing and Distribution (OSDPD)/ Office of Oceanic and Atmospheric Research (OAR)

ORA and OSDPD activities represent a partnership program to provide operational Degree Heating Weeks (DHWs) and HotSpot maps for coral reef bleaching alerts, develop the Tropical Coral Reef Indices page, as well as host a Web-based feedback form. ORA focuses on algorithm development and research, while OSDPD supports data processing and distribution of coral reef products. The ORA led Coral Reef Watch (CRW) initiative combines these satellite-based activities with *in situ* coral reef activities of the National Undersea Research Program (NURP) and the OAR/Atlantic Oceanographic and Meteorological Laboratory (AOML).

3.3.a *Coral Reef Bleaching (Dr. Marguerite Toscano, Ingrid Guch)*

ORA and OSDPD, have formulated and implemented a series of coral reef derived experimental products including HotSpot maps, Degree Heating Weeks images and the Tropical Ocean Coral Reef indices page. OSDPD also hosts a Web-based feedback form to facilitate reports of worldwide bleaching events to NESDIS. These products and the feedback form are located at**:**
http://psbsgi1.nesdis.noaa.gov:8080/PSB/EPS/SST/climohot.html. HotSpot Images highlight regions where sea surface temperature (SST) is 1^{o} C greater than the maximum expected summer temperature. Degree Heating Weeks (DHW) images track the accumulation and distribution of HotSpots over a 90 day period. The DHW index depicts the number of weeks SSTs have been 1^{o} C greater than the maximum expected summer temperature. Major coral bleaching events have been reported for regions where the DHW index exceeds 10. The Tropical Ocean Coral Reef Indices page provides a mechanism for distributing products to the user community. This page summarizes the current temperature and DHW accumulations for selected reefs. A red blinking location indicates a region susceptible to bleaching based on DHW accumulations. These products alert the coral reef community to potential coral reef bleaching episodes. Current activities seek to transition these satellite based products to operational status.

Operational status will ensure the highest quality products and year round technical support.

The Ocean Products Oversight Panel (OPOP) oversees the transfer of products from research to operations. Several issues must be addressed and presented to OPOP before operational status is granted. First, to ensure that products meet the needs of the wider reef community by better representing smaller scale SST variability surrounding reefs, improved product resolution must be examined. Products are now based on a 50 km (nighttime only) resolution operational climatology. ORA is exploring opportunities to upgrade to a 9 km (day and nighttime data) resolution NASA/Jet Propulsion Lab (JPL) Pathfinder Oceans Pathfinder climatology.

Second, the relationship between bleaching and SST indices such as DHWs must be strengthened. To this end, ORA is performing retrospective HotSpot mapping based on 9 km resolution NASA/JPL Oceans Pathfinder data. Fifteen years (1985-1999) of global AVHRR SST data have been processed. Annual composite HotSpot maps have been completed using the maximum monthly mean SST images for that year. Bi-weekly retrospective DHW charts at 50km resolution have been produced for 1998, since this meeting, as have retrospective HotSpot maps at 9km resolution for 1998. Time series SST data will be plotted in relation to maximum monthly mean temperature for specific sites to identify potential past bleaching events and their relation to HotSpots and Degree Heating Weeks. These data will be compared to ground data on past bleaching events where available. In this way, ORA is examining the magnitude and residence time of HotSpots vs. bleaching. This will hopefully allow for formulation of a definitive causal relationship between bleaching and SST. A regionally based early warning system for coral reef bleaching would potentially result. This will require continued ground-truth data reported through the voluntary Web-based report form and gathered through the CRW initiative (see 3.3b) and global collaborations.

Finally, there is a need to revise the way the maximum DHW values for the pre-1998 years are calculated for the Tropical Ocean Coral Bleaching Indices web-page. Currently pre-1998 values are generated by accumulating monthly mean HotSpot data and weighting it by 4.3 to obtain DHW values for each month. The preferred method incorporates newly available, biweekly HotSpot data.

OSDPD proposed the idea of interactive HotSpot maps where users can download satellite SST time-series for a site by clicking on its map location. A similar service is already offered by OSDPD's Satellite Active Archive for 50 km day/night SST fields. OSDPD also mentioned the potential to automatically cue high-resolution SST, HotSpot, and sea-surface wind imagery and associated data when reef areas start to experience thermal stress (SSTs approached 1 degree above the expected summertime maximum) by coordinating with OSDPD's Office of Significant Event Imagery.

ORA/OSDPD coral reef bleaching activities strongly support CRTF National Action Plan objectives to assess and monitor coral reefs, conduct reef research, and create an informed public. (Appendix D)

3.3.b *Coral Reef Watch (CRW) (Dr. Alan Strong)*

The NESDIS led CRW initiative builds a framework for integrating coral reef activities within NESDIS and between NESDIS and other line offices. The goal of this initiative is to establish a satellite based early warning system for coral reef bleaching and health. Under " CRW" NOAA is requesting $ 1.6 million base funds in FY2002 for NESDIS coral reef activities and collaborations with NOS, OAR, and Australian colleagues. This initiative also requests $2.0 million to support the Office of Oceanic and Atmospheric Research (OAR)/ Atlantic Oceanic and Meteorological Laboratory (AOML) and the National Undersea Research Program (NURP) coral reef activities and collaborations.

The NESDIS $1.6 million will support most of NESDIS's coral reef activities to some degree. ORA and OSDPD will receive funding to support their work to transition satellite based coral reef products to operational status and establish the use of SeaWiFS, IKONOS, and Landsat imagery to extend mapping tools (GIS) for determining the spatial range of bleaching. These funds will also support collaboration with NOS, OAR, and Australia colleagues at the Australian Institute of Marine Science (AIMS) and the Great Barrier Reef Marine Park Authority (GBRMPA). Collaborations allow for exchange of expertise, as well as satellite, and *in situ* ground truth data.

A portion of the $1.6 million is designated for NODC to support the expansion of the state-of-the-art CRIDMS (with NOS and OAR). NGDC's work to improve the Coral Reef paleoclimate proxy records will also receive some financial support though this initiative.

The OAR AOML and NURP $ 2.0 million will support the establishment of four to five *in situ* monitoring stations in the Atlantic/Caribbean and the Pacific, to provide near real-time inferencing of *in situ* and satellite data. The remaining funds will assist OAR AOML-NURP with installation of air/water quality sensors at Lee Stocking Island and AQUARIUS (Florida Keys), as well as with the integration of data into existing data management systems.

FY2000 NOAA administration CRW "head start" funding has allowed OAR AOML, ORA, and NURP to begin the installation of a permanent *in situ* coral reef monitoring station at Lee Stocking Island, Bahamas. The FY2000 funds are also supporting the development of a communication server between Australian colleagues and NESDIS/ORA.

CRW establishes a framework for integration of coral reef activities that are mutually beneficial. Integration of NESDIS coral reef activities is called for under this initiative.

3.4 National Ocean Service (NOS) NOS Coral Reef Mapping and Monitoring (Steve Rohmann)

NOS was asked to provide a summary of its coral reef mapping and monitoring activities. NOS reports that only about 5% of the estimated 17,000 sq. kms. of U.S. coral reefs have been mapped to date. Maps of coral reef ecosystems in Puerto Rico and U.S. Virgin Islands are scheduled for completion in March 2001. The addition of these maps will bring the area mapped up to about 15%. In FY2000, an aerial photography mission was conducted over the eight main Hawaiian Islands. Over 550 photos were acquired and will be used for coral mapping.

NOS has made extensive use of on aerial photography as the basis for coral reef mapping. The spatial resolution of photos is considered ideal, when combined with photo interpretation, for identifying as many as 27 categories of benthic features. However, processing the imagery is labor intensive and time consuming. Also, acquiring the aerial photography is expensive and time consuming. This inhibits the use of photography for temporal trend and coral stress analysis. As a result, NOS (with NGDC) is investigating the potential use of satellite sensors for coral reef mapping. Initial maps, based on 30 meter Landsat satellite imagery, show promise for general reef mapping where as many as eight benthic categories can be identified. NOS also has purchased and is assessing high-resolution satellite imagery (IKONOS). This satellite has 1 meter panchromatic and 4 meter multispectral spatial resolution and should enable scientists to identify more categories of benthic habitats. NOS (with NGDC) is also beginning to assess the potential application of airborne hyperspectral data for coral reef mapping. A summary of mapping activities in NOS is posted at http://biogeo.nos.noaa.gov/MIP.

A November 1999 survey reported the character and extent of NOS coral reef monitoring. To view this report, please visit: http://is2.nos.noaa.gov/monitoring/cemc/. This survey revealed that NOS directly performs very little monitoring. NOS's National Marine Sanctuaries conduct some coral reef monitoring, but there is currently no coordinated, systematic effort. NOS's role in coral monitoring has typically been to fund local partners who themselves carry out coral reef monitoring activities. For example, several grants were recently awarded to governments of Pacific and Caribbean island communities to establish funds for coral reef monitoring programs.

NOS representatives and the NESDIS coral reef team agreed that NOAA needs to better identify user needs in terms of data monitoring. A user survey would help set priorities for NOS monitoring funds and the NODC CRDIM system. NOS will conduct this survey this fall. The survey also should reveal if standard data monitoring parameters are available that would facilitate spatial comparisons and establish base-line data.

4.0 DISCUSSION AND ISSUES RAISED

Several discussions ensued throughout the presentation portion of the workshop. Results of those discussions are incorporated in the respective briefing summaries above. Lee Dantzler facilitated post presentation discussions. Each participant was asked to consider the information presented and the CRTF National Action Plan key conservation objectives in answering the following question: In order to support the CRTF National

Action Plan through a NESDIS coral reef team, where should your office focus its coral reef activities?

4.1 NODC

NODC felt the current focus on developing a high-performance Web-site that meets the data needs of the coral reef community was valuable. To reach this goal and ensure that CRIDMS provides parameters pertinent to user needs, NODC suggested that they focus on following the Harmful Algal Bloom (HAB) prototype system. The HAB system developed a data management framework for selected pilot regions. Coral reef pilot regions would coincide with other NESDIS program activities and NOS coral reef monitoring locations. CRTF user surveys will define the priority monitoring parameters in the pilot regions. All recognized the benefits of the pilot project approach and felt it a desirable prototype for the of the larger NESDIS coral reef program. The concentration of efforts in specific regions would allow NESDIS and NOAA to maximize results due to the complimentary nature of NOAA wide coral reef activities.

Additionally, NODC highlighted the need to establish CRIDMS data submission guidelines. This would ensure timely access and a standardized structure to CRIDMS. It was recommended that coral reef monitoring financial assistance awards budget for data set formatting and meta-data development activities.

4.2 NGDC

4.2.a *Paleoclimatology program (Dr. Mark Eakin, Dr. David Anderson, Dr. Christopher Elvidge)*

NGDC encouraged efforts to improve understanding of coral response to climate variability by developing paleo-environmental proxies of this response, long-term environmental time series of coral health, and research projects collecting and correlating short core paleo-records with *in situ* or satellite monitoring data. NGDC stressed the need to increase the dialog with the paleoclimatology community regarding coral reef applications of their work. This would attract deserved research attention.

Collaboration with NOS (monitoring), NODC (data base management), and OAR/OSDPD (satellite SST products) is essential. To promote such collaboration and better define the role of CRIDMS, NGDC suggested hosting a NOAA Coral Reef Data Workshop (Appendix H).

4.2.b *Remote Sensing (Dr. Christopher Elvidge)*

NGDC advocated a focus on hyperspectral (high spectral resolution) coral reef remote sensing. Research in this area would fill an important coral reef remote sensing niche. Both NOS and the CRTF are also interested in developing hyperspectral tools.

The development of hyperspectral reef remote sensing products necessitates collaboration with monitoring efforts and the CRIDMS data distribution center. Both provide ground-

truth data on reef health and water conditions and the later also serves as an avenue for access to hyperspectral products.

Data sets from aerial hyperspectral instruments may ultimately support the development of satellite hyperspectral sensors for coral reef and other applications.

Finally, NGDC expanded on OSDPD's idea to use ORA SST HotSpots to cue the acquisition of high spatial resolution satellite data and products. They suggested this effort be a collaboration between ORA/OSDPD and NGDC and incorporate data from satellites such as Landsat and IKONOS, that could be used to assess coral reef damage level and track recovery.

4.3 ORA/OSDPD- Coral Reef Bleaching and Coral Reef Watch (Dr. Alan Strong, Dr. Marguerite Toscano, and Ingrid Guch)

ORA and OSDPD recommended that a continued focus on transitioning the 50 km hot spot maps and derived products to operational status was appropriate. This will ensure infrastructure support for the desired automated early warning system for coral bleaching events. ORA and OSDPD reiterated the call for higher resolution, 9 km HotSpot maps and stressed the need for NESDIS to expand validation and calibration of satellite SST data through the installation of *in situ* systems and partnerships with national and international colleagues and NOS reef monitoring programs. The Australian/NESDIS collaborative and NESDIS/AOML CREWS joint efforts exemplify partnerships which enhance the value of satellite SST data over reefs and advance the development of an early warning system for bleaching events. Developing a NESDIS coral reef program which partners with NOS coral reef monitoring programs would support efforts to validate and improve satellite coral reef bleaching indices and add a regional perspective to monitoring programs.

Additionally, it was suggested that ORA begin exploring relationships among bleaching, satellite derived SST, and satellite derived wind and ocean color data.

4.4 Collaboration Issues

The following collaboration issues were addressed by workshop members but were left unresolved and open for further discussion:

- The role that the National Coastal Data Development Center (NCDDC) should play in coral reef activities in NESDIS is unresolved.
- The extent of NESDIS coordination of coral reef activities with the National Undersea Research Program (NURP) was not addressed.
- What NESDIS's role should be with the Navy/DoD on coral reef activities needs to be explored.

Other more technical items were introduced at the meeting and also left unresolved. A list of these items can be found in Appendix G.

5.0 SUMMARY

Several themes emerged throughout the workshop briefings and directed discussion. First, NESDIS coral reef team activities combined sufficiently address the CRTF National Action Plan key conservation objectives. It was apparent that joining these complimentary activities in a concerted NESDIS effort would require an integrated NESDIS coral reef program. Part of this program is already being developed under the auspices of the NESDIS led CRW. Second, the region specific prototype strategy arose frequently and favorably. Third, *in situ* monitoring and field research provides a critical component of all NESDIS coral reef activities and should be pursued accordingly. Finally, partnerships among NOAA offices on coral reef initiatives are blossoming. Several NESDIS coral reef team members emphasized the benefits of growing these NOAA and interagency partnerships.

6.0 RECOMMENDATIONS

To advance the coordination and secure the success of a coordinated NESDIS coral reef program, the NESDIS coral reef team member agreed on the following five recommendations.

1) NESDIS should continue its current coral reef activities, while making appropriate changes when necessary to form an integrated NESDIS coral reef program.

2) NESDIS's coral reef-related activities should be conducted within the framework of a larger NOAA partnership. NESDIS should coordinate, where possible, its coral reef program activities (e.g. timing, location, and goals) with coral activities in other NOAA line offices.

3) To facilitate the development of a NOAA-wide coral reef partnership and guide future coral reef activity planning, the workshop recommends developing one to two regionally focused coral reef pilot projects. Pilot project locations should coincide with localities where NOAA coral reef activities converge.

4) Greater overall coordination of NESDIS's coral reef activities with the other NOAA line offices. This is particularly pressing as NOAA strives to provide the national leadership in coral reef ecosystem stewardship and data-information services.

5) Despite major Federal, State, and local efforts in coral reefs, most data on these important ecosystems are poorly organized, scattered and cannot be found online. A follow-on workshop (involving all of the current participants as well as the National Coastal Data Development Center and representatives from other NOAA coral activities) should be convened to address coral reef data management and information services issues.

7.0 APPENDICES

APPENDIX A-Participants

List of workshop participant's names, affiliations, and contact information.

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APPENDIX B

AGENDA

June 2, 2000
Silver Spring, MD
SSMC3 rm. 4817

9 am - 12 noon

Introductory remarks
Presentations by team members (15 minutes each)
Group discussion on presentations (support CRTF key conservation objectives)

12 noon - 1 pm

(LUNCH)- carry out, eat in meeting room
(NOS Briefing by Steve Rohmann)

1pm - 4pm

Identify future activities (requirements and Interagency collaboration).

Summarize recommendations and priorities for future NESDIS coral reef activities

APPENDIX C

Summary of current NESDIS Coral Reef Activities. Information compiled from workshop participants input and distributed prior to the workshop (June 2, 2000).

OFFICE	ACTIVITY	OBJECTIVE	DELIVERABLES	FUNDING (K)	FUNDING SOURCE	FTE's INVOLVED
NGDC-Mapping	Conversion of aerial photography to orthophoto mosaics for coral reef mapping.	Provide technical Support for NOS efforts to map coral reefs in the U.S. and surrounding territories	• Orthophoto mosaics of coral reef areas surrounding Puerto Rico and U.S. Virgin Islands.	$60	NOS	3
NGDC-Mapping	Generation of degraded (1+ m) orthophotos of coral reef areas using DoD satellite imagery.	Support U.S. government and in particular NOAA coral reef mapping activities	• Orthophotos of coral reef areas that are to be mapped by the U.S. program that are inaccessible to the aircraft program due to logistical and cost constraints.	??	??	??
NGDC	Establishment of CRADA focused on hyperspectral remote sensing of coral reef composition and condition.	Develop software tools and spectral libraries for mapping and monitoring coral reefs using hyperspectral remote sensing.	• Capability to analyze coral reef composition and changes in condition over time using spectral libraries. Will be based on the retrieval of benthic reflectance signatures through atmosphere and water.	$100 per year (approximately)	Analytical Imaging and Geophysics LLC.	5
NGDC	Coral Reef Paleoclimatoloy	Support NOAA's mission to improve our understanding of coral reef ecology as well as climate variability and improve future climate predictions	• Scientific data sets of past climate change	$500	Office of Global Programs; National Science Foundation	1 (5-10 principal investigators at academic institutions)

ORA	Coral Reef Satellite SST Monitoring	Utilize space-based observations to monitor for early indications of climate change-induced coral reef bleaching	• Current HotSpot 50km resolution upgraded to 9km • Automated Coral Reef Bleaching alerts • verified/expanded DHW charts	$170 $100	NESDIS/ORA base; Ocean Remote Sensing; NOS	4
ORA/IIA* Australian	NOAA-Australian Collaborative	Establish a Web-based research collaborative	• Internet server • NOAA/Australian MOU	$40	NOAA Administrator	2
NODC	Development of an integrated Global Coral Reef Data and Information Management System	Develop and maintain a Web-accessible, integrated data and information management system on global coral reef ecosystems and associated habitats	• Web-based coral reef data and information management system • A Web-based, GIS, enabled, coral reef assessment and monitoring database • Accurate and accessible archive of global coral reef data sets • An accessible ITIS database of verified scientific names of coral reef species, their synonyms and vernacular names.	$25	NOS	1.8
			TOTAL	**$995**		16.8 FTE's

* Recently funded activity, has yet to be incorporated in CRTF key conservation objectives matrix (APPENDIX D).

APPENDIX D

Matrix summarizing the results of the CRTF National Action Plan key conservation objectives survey. Workshop participants were asked to rate, on a scale of 0-3 (3 being the strongest) the degree to which their coral reef activities support these conservation objectives. The intensity of the grey shade in each box increases with the degree of support. Ratings of zero, no support, are reflected by blank boxes.

	A. Understanding Coral Reef Ecosystems												B. Reduce Adverse Impacts of Human Activities									
	A1. Mapping			A2. Asess/Monitor			A3. Research			A4. Human Dimension			B1. MPA's				B2. Extractive Uses					
Program/Activity	A1a	A1a	A1c	A2a	A2b	A2c	A3a	A3b	A3c	A4a	A4b	A4c	B1a	B1b	B1c	B1d	B2a	B2b	B2c	B2d	B2e	B2e
NGDC Mapping	3	2	2	3	1	1	2	2	1	2	2		2	2	3	2	2	1	1	1	1	2
NGDC Comp. & Condition	3	2	3	3	1	1	3	3	1	2	2		2	2	3	2	3	1	1	1	1	2
NGDC Paleoclimatology			1	1	1		2															
ORA Coral Bleaching		1		3	2	1	1	3	1													1
NODC Information Tech.	2	2	1	2	3	2		1	1		2		1		2	2	2		2	2	1	

	B. Reduce Adverse Impacts of Human Activities																				
	B3. Habitat			B4. Pollution							B5. Restoration					B6. Global Threats				
Program/Activity	B3a	B3b	B3c	B4a	B4b	B4c	B4d	B4e	B4f	B4g	B5a	B5b	B5c	B5d	B5e	B6a	B6b	B6c	B6d	B6e
NGDC Mapping	2	2	2	1	2	2	2	3	2	2	2	2	2	2	1	3	2	2	2	1
NGDC Comp. & Condition	2	2	2	2	2	2	2	3	2	2	2	2	2	2	1	3	2	2	2	1
NGDC Paleoclimatology					1										1		1	1		
ORA Coral Bleaching	1		1				1									2	2	1	3	
NODC Information Tech.	1			1		2	2	1			1		1		1	2	2	1	1	1

	B. Reduce Adverse Impacts of Human Activities																				
	B7. International Trade							B8. Gov. Coordination					B9. Informed Public								
Program/Activity	B7a	B7b	B7c	B7d	B7e	B7f	B7g	B8a	B8b	B8c	B8d	B8e	B9a	B9b	B9c	B9d	B9e	B9f	B9g	B9h	B9i
NGDC Mapping	1	1	2	1	1	1							2	2	2	2	2	2	2	3	2
NGDC Comp. & Condition	1	1	2	1	1	1							2	2	2	2	2	2	2	3	2
NGDC Paleoclimatology		1						1					1			2	1		1		
ORA Coral Bleaching													2	2		3	2		2	2	2
NODC Information Tech.					1						1		3	2	2	3	2	1	1	3	2

Coral Reef Task Force Action Item Table Guide

Values (scale detailed below) describe the degree to which the specified activity fits within the context of the CRTF action item objective.

0= Not related
1= Related to the intent of specified CRTF objective
2= Supporting activity towards achieving specified CRTF objective
3= Critical activity towards achieving specified CRTF objective

A. Understanding Coral Reef Ecosystems

1. **Map all U.S. Coral Reefs**
   a. High Resolution benthic maps
   b. Large-scale, low resolution maps
   c. New technologies and data sources

2. **Monitor, Assess and Inventory Reef Health**
   a. Working closely with partners and stakeholders to develop programs to inventory, assess, and monitor U.S. reefs.
   b. Develop Web-enabled data management and information systems for U.S. reef mapping and monitoring.
   c. Prepare biennial reports on the State of American Coral Reef Ecosystems.

3. **Conduct Strategic Research**
   a. Design and implement a regionally focused competitive research program on natural processes and anthropogenic threats that regulate coral reef health.
   b. Create and interagency Coral Reef Disease Consortium to study, evaluate, track and predict coral disease and bleaching worldwide.
   c. Study impact of management actions on local communities.

4. **Understand the Human Dimension**
   a. Develop regional economic valuations of coral reef ecosystems.
   b. Conduct locally focused socio-economic studies of high-risk anthropogenic threats in specific
   c. U.S coral reef habitats.
   d. Evaluate examples of traditional and community-based coral reef conservation efforts.

B. Reduce the Adverse Impacts of Human Activities

1. **Expand and strengthen the network of coral reef marine protected areas**

a. Accelerate efforts to protect resources within existing MPAs through review and revision of management plans, programs, etc.
b. Establish additional no-take ecological reserves.
c. Conduct a national assessment of the remaining gaps in U.S. coral reef protection and establish new MPAs where needed.
d. Strengthen and support international cooperation among coral reef countries to conserve global biological diversity.

2. Reduce impacts of Extractive Uses

a. Expand network of no-take ecological reserves to identify, monitor, and protect U.S coral Reef fisheries habitat.
b. Reduce fishing impacts.
c. Assess deeper reefs, banks, and beds.
d. Reduce overexploitation of reef organisms.
e. Work with interested entities to explore effective ways to incorporate ecosystem scale considerations into Fisheries Management Plans for coral reef areas.
f. Develop a process to evaluate issues and guidance related to coral reef aquaculture.

3. Reduce habitat destruction

a. Improve federal and state permitting and management programs for coastal development activity by developing technical guidance, impact thresholds and policy directives designed to avoid adverse impacts.
b. Initiate actions at the national and international levels to prevent vessel groundings and other vessel-related impacts.

4. Reduce Pollution

a. Develop informal guidance, protocols and technical assistance programs to reduce damage to corals resulting from federal government activities.
b. Strengthen the scientific rigor and ecological relevance of existing water quality programs and permitting.
c. Develop innovative partnerships with, and provide technical guidance to, governments and users to reduce land-based pollution on a watershed scale.
d. Control point-source pollution from offshore sewage and pipes.
e. Evaluate and address the potential impacts of aerial atmospheric nutrient and pollution deposition.
f. Prevent, prepare for, and respond to oil and chemical spills to reduce reef impacts.
g. Clean up existing concentrations of marine debris and address known future sources.
h. Evaluate and mitigate major pathways of alien species invasion.

5. Restore injured and degraded habitats

a. Review and evaluated existing reef restoration projects to quantify the extent to which they expedite recovery, and make improvement recommendations.

b. Develop and test innovative methods and techniques to expedite reef restoration.
c. Develop regional restoration plans.
d. Based on the review of restoration approaches, promote cost-effective pilot restoration of selected degraded U.S. reefs.
e. Transfer proven restoration tools, techniques, and lessons learned to domestic and international partners.

6. **Reduce global threats to coral reefs**
a. Exercise global leadership in the international arena by addressing international threats to coral reef ecosystems.
b. Strengthen the International Coral Reef Initiative and implement its renewed Call to Action, and support the Global Coral Reef Monitoring Network.
c. Provide assistance in managing and conserving reef ecosystems and their watersheds in the Wider Caribbean, the Pacific, South East Asia, East Africa, and Middle East region.
d. Strengthen international efforts aimed at understanding, predicting, preventing and responding effectively to the impacts of large-scale phenomena and their socioeconomic impacts
e. Analyze and address unsustainable and destructive fishing practices and unsustainable international trade in coral reef and mangrove species.

7. **Reduce impacts of international trade in coral reef resources**
a. Continue to actively participate in regional fora addressing concerns related to coral reef species trade as well as raise awareness of this problem.
b. Continue consultations with coral exporting countries and other stakeholders to assess problems associated with trade in coral reef species.
c. Expand capacity-building efforts in countries with coral reefs to reduce impacts of activities in coral reefs.
d. Improve domestic law enforcement of illegal coral reef species trade.
e. Work with various stakeholders to develop public education and awareness materials aimed at reducing unsustainable harvest practices.
f. Work with the marine aquarium industry and various stakeholders to eliminate destructive collection practices and reduce mortality during handling and transport of reef species.
g. Provide measures to ensure that U.S. consumer demand for marine aquarium organisms does not threaten the sustainability of reef species and ecosystems.

8. **Improve governmental coordination and accountability**
a. Coordinate the submission of Coral Reef Protection Implementation Plans by CRTF member agencies.
b. Coordinate joint planning and development of crosscutting budget initiatives on coral reef conservation.
c. Coordinate the annual submission of agency reports of programs, policies and actions.

d. Coordinate the process for the public inquiry about, and agency response to, issues or concerns relating to federal agency actions and coral reef protection.
e. Working with the Council on Environmental Quality, assist member agencies and other interested entities to develop guidance for the inclusion of coral reef protection in environmental documents prepared under the National Environmental Policy Act (NEPA).

9. Create and informed public

a. Increase national and international awareness of the ecological, economical and cultural importance of coral reefs.
b. Inform local and regional audiences of the linkage between their actions and local coral reef health.
c. Educate specific user groups about ways to minimize the impacts of their specific activity.
d. Provide information to coastal decision-makers to influence reef conservation issues at the local, regional and national levels.
e. Increase awareness of and support for the actions proposed by the U.S. Coral Reef Task Force.
f. Establish a CRTF Education Coordinator to act as a key member of the CRTF Staff, and to plan and coordinate Task Force education efforts on national and local scales.
g. Utilize and build upon existing material and successful outreach activities developed during the International Year of the Ocean and Year of the Reef campaigns with governmental agencies and NGOs.
h. Work with NGOs, Federal agencies, educational institutions, States and Territories, and the scientific community to compile information on reef resources.
i. Coordinate with all national and international campaigns focused on protecting coral reefs.

APPENDIX E

Summary of data accessible from web-sites of various coral reef programs and that proposed for NODC's CRIDMS.

	CRDIMS	CARI-COMP	CHAMP	CCC	GCRMN	AGRRA	CRAMP	FKNMS	AIMS	HI FWS
database	P	A	A	A	A	P	A	A	A	P
data archive	A									
near real time data	P		A							
historical data	A		A						A	
monitoring data	A	A	A	A	A	A	A	A	A	A
fisheries data	P				A					A
volunteer survey data	A			A	A					
data summaries	A	A			A		A		A	
reef location data	A				A		A	A	A	
reef maps	A		A		A		A	A	A	
images (photo or video)	A									
status reports		A			A			A	A	
species listing	A							A	A	
methods listing	P		A	A			A		A	
regulation listing			A					A		
protected areas listing	P				A					
bulletins			A							
list server			A							
coral reef bibliography			A				P			
dictionary of terms	A									
educational programs								A	A	

A = Available
P = Proposed

MEANINGS OF ACRONYMS:

CRDIMS
Coral Reef Data and Information Management System
NOAA/National Oceanographic Data Center
www.nodc.noaa.gov/col/projects/coral/Coralhome.html

CARICOMP
Caribbean Coastal Marine Productivity
Data Management Center
www.uwimona.edu.jm/centres/cms/caricomp/

CHAMP
Coral Health and Monitoring Program
www.coral.aoml.noaa.gov

CCC
Coral Cay Conservation
www.coralcay.demon.co.uk/

GCRMN
Global Coral Reef Monitoring Network, ReefBase
reef.aoml.noaa.gov/icri/gcrmn.html

CRAMP
Coral Reef Assessment and Monitoring Program
Hawaii
www.cramp.wcc.hawaii.edu

FKNMS
Florida Keys National Marine Sanctuary
www.fknms.nos.noaa.gov

AIMS
Australian Institute for Marine Sciences
www.aims.gov.au

HI FWS
U.S. Fish and Wildlife Service, Hawaii
pacific.fws.gov

APPENDIX F

Core functions the NODC proposed CRIDMS must meet:

1. Acquire coral reef-related data from national and international sources.

2. Describe each accession of data following Federal Geographic Data Committee (FGDC) metadata standards and include this metadata record with data distribution.

3. Ingest each accession of data into the NODC magneto-optical plotter archives. Routinely scan the archive for completeness of accessions and viruses, and when needed, migrate the entire archive onto state of the art storage media. This establishes a **permanent** repository for coral reef data.

4. Prepare a copy of each accession for loading into a relational database.

5. Perform Quality Control/Quality Assurance (QC/QA) tests on each accession. Flag all data values outside a range determined by scientific experts.

6. Maintain Web-based spatial, temporal, and text query tools for contents of the CRDIMS database allowing immediate download of data in useable formats.

7. Prepare data for export into a geographical information system (GIS)

8. Display station locations, reef locations, and gridded data sets using a Web-based geographical information system (GIS).

9. Prepare, upon request of the user community, data products for specific reef systems and/or specific coral reef research topics. These can be Web-based systems or CD-ROM products.

10. Assist with development, installation, and use of inexpensive data exchange software for small groups of researchers or managers.

11. Develop a common gateway for users to access and fuse together data from a distributed network of coral reef related databases.

APPENDIX G

Several items addressed at the workshop were left open for discussion. The list below highlights several issues that must be addressed in detail as the coral reef team activities progress.

Open For Discussion:
CRIDIMS items:

1) Web site organization

2) Data clearinghouse?
   US Global Change Research Program analogy-
   water resources example

3) Data rescue - even short monitoring studies and old maps/photos?

4) User needs -- not always GIS, not always Web based

5) NODC long term archive?

Mapping and Monitoring items:

1) Mapping time series queried from interactive ORA coral bleaching Web-site

2) Satellite and aerial image calibration- expanded *in situ* validations

3) Higher resolution maps and products? Issue of location errors at fine scale?

4) Experimental vs. Operational definitions: applies to what data

5) IKONOS in non-US waters -- how do we fund this?

6) Near-real time data availability and archive

4) Intergovernmental Panel on Climate Change (IPCC) 2000 Assessment -- effect of global climate change on corals

APPENDIX H

The following captures the initial proposal for a NOAA Coral Reef Data Management Workshop:

Purpose: A Meeting to Design Data Acquisition and Management Systems to Meet the Needs of the NOAA-wide Coral Reef Community and U.S. Coral Reef Task Force

Background: The U.S. Coral Reef Task Force (CRTF) was established by President Clinton in June 1998 though Executive Order #13089 on Coral Reef Protection to lead the U.S. response to this growing, global environmental crisis. The CRTF is responsible for overseeing implementation of the Executive Order, and developing and implementing coordinated efforts to:

- map and monitor U.S. coral reefs;
- research the causes and solutions to coral reef degradation;
- reduce and mitigate coral reef degradation from pollution, over fishing and other causes;
- implement strategies to promote conservation and sustainable use of coral reefs internationally.

Despite major Federal, state and local efforts in coral reefs, most data on these important ecosystems are poorly organized, scattered and cannot be found online. NOAA data will play a prominent role in many of the activities proposed by the CRTF, as well as the activities of state and local governments.

NESDIS proposes to hold a workshop to identify the coral reef data needs of NOAA, other Federal agencies, CRTF partners and academia. NODC has already begun to develop a coral reef data and information management system that will integrate biological data from reef ecosystem monitoring and research programs with interrelated chemical, biological and physical data of surrounding marine areas. NESDIS's Oceanic Research and Applications Division has developed Hotspot systems to provide early warnings of bleaching and other satellite products. NGDC maintains paleo-environmental data from corals that provide the long baseline of environmental variability in the tropical coral reef environment. The National Marine Sanctuaries and NURP maintain data from individual sites. NMFS has data on a variety of reef sites throughout U.S. waters. NOS and NGDC have developed or are developing maps of U.S. coral reef areas. What NOAA lacks is an organized plan for how to manage these varied data and to make these available to users ranging from NOAA scientists to resource managers, to reef visitors, to local and regional policy and decision-makers.

The purpose of this workshop will be to determine:

- What are the existing holdings of coral reef data within NOAA?
- What data products is NOAA either producing or planning to produce?
- What data do NOAA resource managers and scientists need to access?
- What data does NOAA need to make available to a broader suite of users?

- How should NESDIS manage and provide access to these data so that NOAA and National goals are best served ?

It is anticipated that the workshop should include representatives of NOAA scientific and management groups with significant holdings of coral reef data, of NOAA data centers, of NOAA and other resource managers and of other Federal agencies involved in the CRTF and with relevant expertise.